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An Appraisal of Efficient Routing Protocols in Wireless Sensor Networks

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Abstract:-In wireless sensor network,sensor nodes has limited energy and communication ability due to which it is important to design a routing protocol.Routing protocol helps to increases network lifetime of wireless sensor network. This paper contains various existing routing protocol techniques.

Keywords—WSN,LEACH,TEEN.APTEEN, location-based routing protocol

I. INTRODUCTION

Wireless sensor networks[14] is widely considered as one of the most important technologies.In Wireless sensor network, sensor nodes are used for gathering data and transmitting to sink but sensor nodes has limited energy and communication ability.So, it is important to design a routing protocol for WSNs[13] so that sensing data can be transmitted efficiently.it balances the energy consumption and increases the network lifetime and guarantees high QoS of WSN[8].Routing protocols are used for finding and keeping the routes in the network. Various categories of routing protocols are Flat protocols, Hierarchical protocol, Location based protocols which is used for balance the energy consumption and increases the network lifetime

II. WSN ROUTING PROTOCOLS

In WSNs [4] depending on network structure routing is divided into three categories i.e. flat based routing, hierarchical routing and location based routing. All nodes in a flat routing protocol are assigned equal roles or functionality and the nodes collaborate to perform the sensing tasks. The sink sends queries to certain regions within the WSN and awaits data from the sensors located in that region. SPIN and directed diffusion are examples of flat routing protocols .

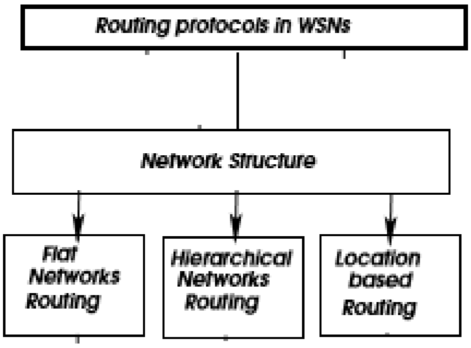

Figure 1 Routing Protocols In WSN [5]

Location of sensor nodes is essential to measure the distance between neighboring nodes. If the location of sensor nodes are known then data transmission only occurs on that region to reduce the number of transmissions. The most important routing protocol used as location routing protocols are GAF and GEAR.In hierarchical routing protocols[11], clusters are created and a head node is assigned to each cluster. The head nodes are the leaders of their groups having responsibilities like collection and aggregation the data from their respective clusters and transmitting the aggregated data to the Base Station. This data aggregation in the head nodes greatly reduces energy consumption in the network (CH) and the CH transmits the data to the global Base station or sink. This reduces the transmission range of normal nodes to conserve energy. Figure 1 shows the various routing techniques in WSNs.

III. CHALLENGES OF CLUSTERING

Wireless Sensor Networks present vast challenges in terms of implementation. There are several key attributes that designers must carefully consider, which are of particular importance in wireless sensor networks.

- Cost of Clustering
- Selection of Cluster heads and Clusters

- Real-Time Operation
- Synchronization
- Data Aggregation
- Repair Mechanisms
- Quality of Service (QoS)

IV. FLAT ROUTING TECHNIQUES

The first technique of routing protocols[7] is flat routing protocols. In flat networks[4], each node typically plays the same role and sensor nodes collaborate together to perform the sensing task.This consideration has led to data centric routing, where the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data. Two most commonly used flat routing protocols are:-

- SPIN(Sensor Protocols For Information Via Negotiation)
- Minimum Cost Forwarding Algorithm (MCFA)

4.1 SENSOR PROTOCOLS FOR INFORMATION VIA NEGOTIATION:-

The SPIN[5] family of protocols are used to efficiently disseminate information in a wireless sensor network. Conventional data dissemination approaches like flooding and gossiping waste valuable communication and energy resources sending redundant information throughout the network. In addition, these protocols are not resource-aware or resource-adaptive. SPIN[10] solves these shortcomings of conventional approaches using data negotiation and resource-adaptive algorithms. Nodes running SPIN assign a high-level name to their data, called meta-data, and perform meta-data negotiations before any data is transmitted. This assures that there is no redundant data sent throughout the network. In addition, SPIN has access to the current energy level of the node and adapts the protocol it is running based on how much energy is remaining. Simulation results show that SPIN is more energy-efficient than flooding or gossiping while distributing data at the same rate or faster than either of these protocols.

4.2 Minimum Cost Forwarding Algorithm (MCFA):-

The MCFA algorithm [18] exploits the fact that the direction of routing is always known, that is, towards the fixed external base-station. Hence, a sensor node need not have a unique ID nor maintain a routing table. Instead, each node maintains the least cost estimate from itself to the base-station. Each message to be forwarded by the sensor node is broadcast to its neighbors. When a node receives the message, it checks if it is on the least cost path between the source sensor node and the base-station. If this is the case, it re-broadcasts the message to its neighbors. This process repeats until the base-station is reached.

In MCFA, each node should know the least cost path estimate from itself to the base-station. This is obtained as follows. The base-station broadcasts a message with the cost set to zero while every node initially set its least cost to the base-station to infinity (∞). Each node, upon receiving the broadcast message originated at the base-station, checks to see if the estimate in the message plus the link on which it is received is less than the current estimate. If yes, the current estimate and the estimate in the broadcast message are updated. If the received broadcast message is updated, then it is re-sent; otherwise, it is purged and nothing further is done. However, the previous procedure may result in some nodes having multiple updates and those nodes far away from the base-station will get more updates from those closer to the base-station. To avoid this, the MCFA was modified to run a backoff algorithm at the setup phase.

V. HIERARCHICAL PROTOCOL

In hierarchical routing protocols[12], clusters are created and a head node is assigned to each cluster. the head nodes are the leaders of their groups having responsibilities like collection and aggregation the data from their respective clusters and transmitting the aggregated data to the sink. this data aggregation in the head nodes greatly reduces energy consumption in the network by minimizing the total data to be sent to sink. the less the energy consumption, the more the network life time. The main idea of developing cluster-based routing protocols[6]is to reduce the network traffic toward the sink.

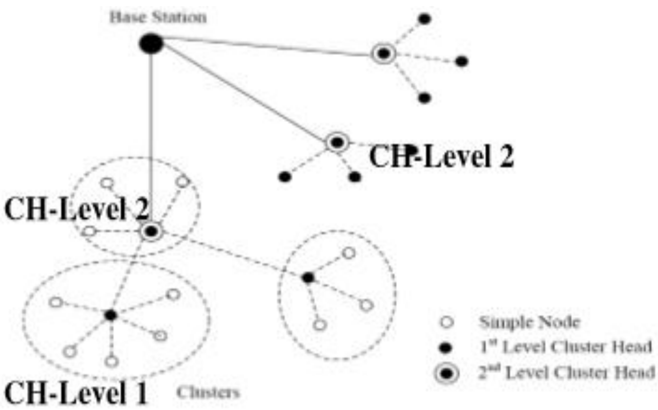

Figure Cluster based hierarchical model[16] a hierarchical approach breaks the network into clustered layers . Nodes are grouped into clusters with a cluster head that has the responsibility of routing from the cluster to the other cluster heads or base stations. Data travel from a lower clustered layer to a higher one. Although, it hops from one node to another, but as it hops from one layer to another it covers larger distances. This moves the data faster to the base station. Clustering provides inherent optimization capabilities at the cluster heads. Commonly used hierarchical protocols are

i. **LEACH Protocol**
ii. **TEEN**
iii. **APTEEN**
iv. **Energy Efficient Clustering Scheme**

5,1 LEACH PROTOCOL

Low energy adaptive clustering hierarchical protocol is self organizing clustering protocol. The protocol is divided into two phases:-

i. **Setup phase**
ii. **Steady-state phase**

The protocol is divided into a setup phase when the clusters are organized themselves,in steady-state phase data are transferred from the nodes to the cluster head and on to the sink [5]. In the setup phase, each node choose a random number between 0 and 1,if this number is less than a certain threshold T(n),the node will act as the cluster head.The non cluster head node chooses the cluster head with greater signal strength and join the cluster, and after the formation of cluster and cluster head node, cluster head node receives data from all of the cluster members and transmits data to the sink.

During the setup phase, a predetermined fraction of nodes, p, elect themselves as CHs as follows. A sensor node chooses a random number, r, between 0 and 1. If this random number is less than a threshold value, T(n), the node becomes a cluster-head for the current round. The threshold value is calculated based on an equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, denoted by G. It is given by[4]:

$$T(n) = \begin{cases} \dfrac{p}{1 - p \ mod \left[\frac{1}{p}\right]} & n \in G \\ 0 & otherwise \end{cases}$$

where G is the set of nodes that are involved in the CH election. These working of LEACH shown in Figure 2.

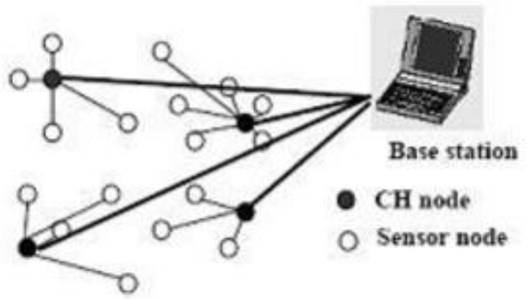

Figure 2 Working of LEACH [4]

During the steady state phase, the sensor nodes can begin sensing and transmitting data to the cluster-heads. The cluster-head node, after receiving all the data, aggregates it before sending it to the base-station. After a certain time, the network goes back into the setup phase again and enters another round of selecting new CH.

5.3 TEEN Protocol

Threshold sensitive Energy Efficient sensor Network protocol (TEEN)[15], is a hybrid of hierarchical clustering and data-centric protocols designed for time-critical applications. It is a responsive protocol to sudden changes of some of the attributes observed in the WSN (e.g., temperature).The algorithm first goes through cluster formation. The CHs then broadcast two thresholds to the nodes in their clusters. Those are hard and soft thresholds for the sensed attribute:

- **Hard Threshold (HT):-**

This is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its cluster head.

- **Soft Threshold (ST):-**

This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit. It stimulates the node to switch on its transmitter and report the sensed data. A node will report data only when the sensed value is beyond the HT or the change in the value is greater than the ST. However, TEEN[15] cannot be applied for sensor networks where periodic sensor readings should be delivered to the Sink, since the values of the attributes may not reach the threshold at all. Moreover, we have some wasted time-slots in TEEN protocol and there is always a possibility that the sink may not be able to distinguish dead nodes from alive ones. Another limitation of the protocol is that the message propagation is accomplished by CHs only. If CHs are not in each others transmission radius, the messages will be lost.

5.4 APTEEN

The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) [15] is an extension to TEEN and aims at both capturing periodic data collections and reacting to time critical events. The architecture is same as in TEEN. When the base station forms the clusters, the cluster heads broadcast the attributes, the threshold values, and the transmission schedule to all nodes. Cluster heads also perform data aggregation in order to save energy. APTEEN supports three different query types: historical, to analyze past data values; one-time, to take a snapshot view of the network; and persistent to monitor an event for a period of time.

5.5 ENERGY EFFICIENT CLUSTERING SCHEME:-

An Energy Efficient Clustering Scheme (EECS)[6] is a clustering algorithm in which cluster head node compete for the ability to elevate to cluster head for a given round. This competition involves nodes broadcasting their residual energy to neighboring candidates. If a given node does not find a node with more residual energy, it becomes a cluster head. Cluster formation in EECS is different from LEACH. In LEACH cluster head formed on the basis of mininum distance between node to the cluster head. EECS extends this algorithm by dynamic sizing of clusters based on cluster distance from the base station.in EECS cluster formation is similar like LEACH, where in EECS the network is partitioned into a set of clusters with one cluster head in each cluster. There is direct Communication between cluster head and Sink.In the network deployment phase, the Sink broadcasts a “hello” message to all the nodes at a certain power level. By this way each node can compute the approximate distance to the sink based on the received signal strength. It helps nodes to select the proper power level to communicate with the sink. Also this distance is used to balance the load among cluster heads.

VI. LOCATION BASED PROTOCOL

In Location based or position based routing[5] protocol sensor nodes are addressed by means of their locations.Location information for sensor nodes is required for sensor networks by most of the routing protocols to calculate the distance between two particular nodes so that energy consumption can be estimated.

i. Geographic Adaptive Fidelity(GAF)

ii. Geographic and Energy Aware Routing (GEAR)

6.1 GEOGRAPHIC ADAPTIVE FIDELITY(GAF):-

Geographic Adaptive Fidelity or GAF[1] is an energy- aware location-based routing algorithm designed primarily for mobile ad hoc networks, but is used in sensor networks as well. This protocol aims at optimizing the performance of wireless sensor networks by identifying equivalent nodes with respect to forwarding packets. In GAF[3] protocol, each node uses location information based on GPS to associate itself with a “virtual grid” so that the entire area is divided into several square grids, and the node with the highest residual energy within each grid becomes the master of the grid. Two nodes are considered to be equivalent when they maintain the same set of neighbor nodes and so they can belong to the same communication routes. Source and destination in the application are excluded from this characterization.

Nodes use their GPS-indicated location to associate itself with a point in the virtual grid. Inside each zone, nodes collaborate with each other to play different roles. For example, nodes will elect one sensor node to stay awake for a certain period of time and then they go to sleep. This node is responsible for monitoring and reporting data to the sink on behalf of the nodes in the zone and is known as the master node. Other nodes in the same grid can be regarded as redundant with respect to forwarding packets, and thus they can be safely put to sleep without sacrificing the “routing fidelity” or routing efficiency.

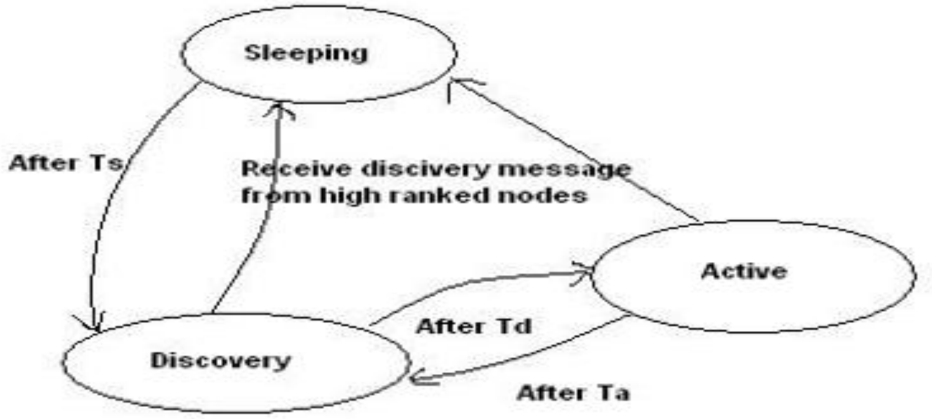

Figure 3 State Transition In GAF Protocol [1]

There are three states defined in GAF as shown in Figure 3,These states are discovery, for determining the neighbors in the grid, active reflecting participation in routing and sleep when the radio is turned off. In order to handle the mobility, each node in the grid estimates it’s leaving time of grid and sends this to its neighbors. The sleeping neighbors adjust their sleeping time accordingly in order to keep the routing fidelity. Before the leaving time of the active node expires, sleeping nodes wake up and one of them becomes active.

6.2 GEOGRAPHIC AND ENERGY AWARE ROUTING (GEAR) : -

It is Energy-efficient routing protocol used for routing queries to target regions in a sensor field, sensors are aware of their residual energy as well as the locations and residual energy of each of their neighbors. It uses energy aware and geographically-informed neighbor selection heuristics to route a packet towards the destination region. The key idea is to restrict the number of interests in directed diffusion by only considering a certain region rather than sending the interests to the whole network. By doing this, GEAR can conserve more energy than directed diffusion.

In GEAR[1], each node keeps an estimated cost and a learning cost of reaching the destination through its neighbors. The estimated cost is a combination of residual energy and distance to destination. The learned cost is a refinement of the estimated cost that accounts for routing around holes in the network. A hole occurs when a node does not have any closer neighbor to the target region than itself. If there are no holes, the estimated cost is equal to the learned cost. The learned cost is propagated one hop back every time a packet reaches the destination so that route setup for next packet will be adjusted. Figure 4 shows the Recursive Geographic Forwarding In GEAR. The process of forwarding a packet to all the nodes in the target region consists of two phases:

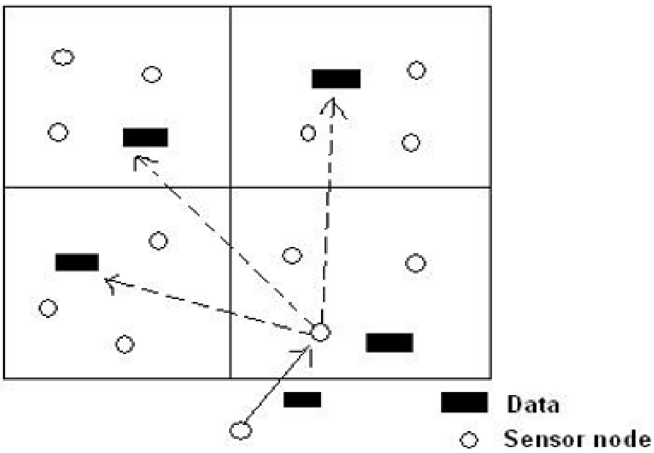

Figure 4 Recursive Geographic Forwarding in GEAR [1]

- **Forwarding packets towards target region:-**

Upon receiving a packet, a node checks its neighbors to see if there is one neighbor, which is closer to the target region than itself. If there is more than one, the nearest neighbor to the target region is selected as the next hop. If they are all further than the node itself, this means there is a hole.In this case, one of the neighbors is picked to forward the packet based on the learning cost function.

- **Forwarding packets within target region:-**

If the packet has reached the region, it can be diffused in that region by either recursive geographic forwarding or restricted flooding. Restricted flooding is good when the sensors are not densely deployed. In high- density networks, recursive geographic flooding is more energy efficient than restricted flooding. In that case, the region is divided into four sub regions and four copies of the packet are created. This splitting and forwarding process continues until the regions with only one node are left.

VII. CONCLUSION

In this paper, survey of routing techniques in wireless sensor networks is done. The routing techniques are classified into three categories: flat, hierarchical, and location based routing protocols.Different protocols belong to these categories are analyzed in depth and their methods are studied. These protocols improve the working of WSN by increasing its life and network efficiency to a certain extent.

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